

Liu et al.
Serial No. 09/208,963
Filed December 10, 1998

of record were discussed, particularly the impact of Zr on final alloy product properties. The essence of that discussion is summarized below.

The Amendment filed August 14, 2001 details that the Karabin et al. patent discloses an aluminum alloy similar to the presently claimed alloy except that the alloy of the Karabin et al. patent contains Zr. It has already been established on the record of this application that inclusion of Zr leads to an aluminum alloy product that has an unrecrystallized grain structure. In the typical manufacturing process for plate products, after ingot casting, homogenization, and hot rolling, the resulting product has unrecrystallized grains which are deformed, i.e., appear flattened from the hot rolling step. Upon solution heat treatment, the natural tendency is for the deformed grains to undergo recrystallization by nucleation and growth of strain-free grains which consume the deformed grains and ultimately result in a recrystallized grain structure in the final plate product. Prior to the present invention, the conventional teaching was that product with recrystallized grain structure has insufficient properties, such as poor fracture toughness, while an alloy with unrecrystallized grain structure provides sufficient physical properties to the final product. Accordingly, Zr is conventionally introduced into an alloy to pin the grain boundaries of the recrystallization nuclei, as taught by the Karabin et al. patent at col. 10, ll. 3-5.

The Karabin et al. patent expressly teaches at col. 6, ll. 43-55 that important properties for aerospace alloys (including fracture toughness) are achieved by careful control of the alloy composition, the process thereof and its unrecrystallized grain structure. The criticality of unrecrystallized grain structure is taught throughout the Karabin et al. patent, e.g., in the abstract, col. 2, ll. 47 and 55, col. 5, ll. 9 and 44, and col. 9, l. 49. Hence, the Karabin et al.

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Liu et al.
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patent teaches that an unrecrystallized grain structure is critical to the final product properties and the inclusion of Zr leads to the unrecrystallized state.

The Colvin et al. patent supports the teachings of the Karabin et al. patent. As detailed in the Amendment filed August 14, 2001, the Colvin et al. patent indicates that Zr may be added to an alloy if an unrecrystallized grain structure is desired. However, at levels of over about 0.12% Zr, coarse Zr-bearing particles may form which can be detrimental to toughness. In other words, addition of Zr can be helpful when an unrecrystallized grain structure is sought (per the Karabin et al. patent), but too much Zr is harmful. The Colvin et al. patent only cautions against using too much Zr.

Despite these teachings by Karabin et al. (obtain desired unrecrystallized grain structure for suitable properties by including Zr) and Colvin et al. (Zr provides unrecrystallized grain structure), Applicants developed the claimed alloy which lacks Zr and, hence, has a recrystallized grain structure yet exhibits unexpectedly superior physical properties.

A comparison of the fracture toughness of the alloy of the Karabin et al. patent (containing Zr) and the claimed alloy (without Zr) is as follows:

	Karabin et al.	Invention
Grain structure	Unrecrystallized (with Zr)	Recrystallized (no Zr)
K _{IC}	43*	45**

* Data from Table 1.

** Data from Fig. 1.

Even though the alloy of the present invention does not include Zr (hence, is recrystallized), its properties are unexpectedly improved over the alloy of the Karabin et al. patent. Applicants developed an alloy without Zr for aerospace products which is directly

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counter to the prior conventional wisdom to include Zr, yet discovered improvements in the new alloy's physical properties.

Applicants deleted both an element (Zr) and its function (unrecrystallized grain structure) despite the established teachings that the function of Zr is required to achieve appropriate physical properties. In such a situation, the surprising result of eliminating a supposedly critical feature of the prior art alloy (unrecrystallized grain structure) demonstrates unobviousness of the claimed alloy.

Accordingly, the claimed alloy which excludes Zr is a patentable advance over the prior art of record.

In the Interview, it was suggested by the Examiners that the claims should specify a product type (e.g., plate) for the alloy to render it clear that the superior properties claimed are found in a final product. Applicants have adopted the Examiners' suggestion by adding the term "plate" to independent claims 1 and 2. Support therefor appears in the Field of the Invention.

Finally, a typographical error in the formula of claim 1 is corrected. No new matter has been added.

In view of the Amendment filed August 14, 2001, the Interview of October 26, 2001, and the foregoing, allowance of claims 1-40 is respectfully requested.

No fee is believed to be due, but the Assistant Commissioner for Patents is hereby authorized to charge any additional fees which may be required to Deposit Account No. 23-0650.

Respectfully submitted,



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Liu et al.
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Marked-Up Claims

1. (Four Times Amended) A 2000 series aluminum plate alloy consisting essentially of in weight percent about 3.60 to 4.25 copper, about 1.00 to 1.60 magnesium, about 0.30 to 0.80 manganese, no greater than about 0.05 silicon, no greater than about 0.07 iron, no greater than about 0.06 titanium, no greater than about 0.002 beryllium, the remainder aluminum and incidental elements and impurities, wherein a T_{\max} heat treatment is below the lowest incipient melting temperature for a given 2000 series alloy composition and the Cu_{target} is determined by the expression:

$$Cu_{\text{target}} = Cu_{\text{eff}} + 0.74(Mn - 0.2) + 2.28(Fe - 0.005)$$

wherein said alloy improves by a minimum of 5% compared to the average values of standard 2324-T39 alloy shown in Fig. 1 for the same properties selected from the group consisting of the plane strain fracture toughness, K_{Ic} , the plane stress fracture toughness, K_{app} , the stress intensity factor range, ΔK , at a fatigue crack growth rate of 10 μ -inch/cycle wherein $R=0.1$ and RH is greater than 90%, and combinations thereof.

2. (Twice Amended) A 2000 series aluminum plate alloy consisting essentially of a composition within the box of W, X, Y, and Z as defined in Fig. 5, wherein T_{\max} for each composition corner point is $W = 925^{\circ}\text{F}$, $X = 933^{\circ}\text{F}$, $Y = 917^{\circ}\text{F}$, and $Z = 909^{\circ}\text{F}$, wherein Cu_{target} is defined by the following equation:

$$Cu_{\text{target}} = Cu_{\text{eff}} + 0.74(Mn - [.03] \underline{0.2}) + 2.28(Fe - 0.005).$$